Nantucket Harbor Water Quality
Annual Report
2005

Prepared for:

Marine and Coastal Resources Department
34 Washington St.
Nantucket, MA. 02554

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Introduction:

Nantucket Harbor has an approximate surface area of 5,250 acres and basin volume of 50, 990 acre-ft. Nantucket Harbor is comprised of three large basins each connected by a narrow race- way with two additional lobes, called Polpis Harbor. Within Nantucket Harbor, Polpis Harbor has a surface area of 177 acres and basin volume of 923 acre-ft. Polpis Harbor is a large collector of runoff from the harbor watershed, and as such, is a nutrient and bacteria source for Nantucket Harbor.

Water quality and circulation studies have been documented since 1990 and monitored prior. Woods Hole Institute, Ecosystems Consulting Service Inc. of CT., Aquatic Ecosystems, also from Ct., Applied Science Associates of RI., and The School of Marine Science and Technology under the Massachusetts Estuary Project under the direction of the Department of Environmental Protection have all done extensive investigations of Nantucket Harbor. Water quality results indicate that nutrients are increasing; and being recycled in the Head of the Harbor, and Quaise Basin. Polpis Harbor has contributed to the decline in water quality in Quaise Basin, as nutrients are continuing to be loaded from the harbor watershed. Though the Town area is sewered, the mooring field area in some years is a large source of phosphorus; as run off the storm drains and Consue Srpings carry whatever contaminants may be in the surface water.

Nantucket is not alone in the degradation of it's harbor water quality. There have been serious declines in water quality in all coastal communities due to anthropogenic nutrient overloading. Although coastal ecosystems have the capacity to assimilate some level of nutrient input without major changes in the ecological health, most coastal communities have exceeded this ability. The Town of Nantucket has made discernable efforts to understand and remediate this eutrophication process, however a noticeable declining trend continues. The Town will continue to monitor these trends in order to mitigate these processes associated with development, and our uses of the Island's resources.

As nitrogen and phosphorus concentrations increase, the natural eutrophication process is accelerated. This process results in excessive aquatic plant growth (phytoplankton, macro and epiphytic algae); especially in a poorly flushed shallow coastal embayment. Photosynthesis is increased during the day, but respiration is also increased during the night. And when this over abundant plant growth dies, its decomposition uses up the available dissolved oxygen and increases the creation of anoxic conditions. Nutrients are then released from the sediments into the water column. The continued addition of nutrients and acceleration of plant growth leads to further decomposition by anaerobic bacteria (bacteria that don't require oxygen). The result is an embayment bottom coated with an organic mud residue (i.e. Wauwinet, Polpis, Quaise, Pocomo flats). Light penetration decreases, and a habitat, once desirable for shellfish and finfish, is now unsuitable for spawning, development, and life.

For many years 1992-2004, the Marine and Coastal Resource Department biologist, Tracy Curley, gathered nutrient information for Nantucket Harbor and its' watershed drainage basin. Harbor sampling includes temperature, dissolved oxygen, salinity, water transparency, water quality constituents (nitrogen and phosphorus), and phytoplankton. Harbor monitoring also includes similar data collected from the streams that flow into the upper and middle harbor areas.

The Nantucket Harbor water quality stations are as follows: **Site 1:** Mooring Field, **Site 2:** Quaise Basin, **Site 3:** Head of Harbor, **Site 4:** Nantucket Sound, **Site 5:** Polpis West, and **Site 6:** Polpis East. These locations are designated on **Map #1**.

The stream stations are located on **Map #2**, and are as follows: **Stream 1:** flows into the Head of the Harbor, **Stream 2:** flows into Medouie Creek, **Stream 3:** flows into Polpis East, **Stream 4:** flows into Polpis East, draining Cranberry Bog, **Stream 5:** flows into Polpis West, draining swamp near cemetery, **Stream 6a:** flows into Polpis West, **Stream 6b:** flows into Polpis West, **Stream 6c:** flows into Polpis West, draining Duck Pond, **Stream 7:** flows into Quaise, **Stream 8:** flows into Fulling Mill Brook, next to Life Saving Museum.

Harbor Monitoring Results:

Appendix A: contains all harbor water quality data. **Appendix B:** contains the averages of A with corresponding charts. **Appendix C:** contains all stream data for the upper and middle harbor watershed. **Appendix D:** contains the average total nitrogen and phosphorus loading from C. **Appendix E:** contains the average monthly rainfall for 2005, as collected by the Nantucket Water Company.

Average Temperatures and Average Dissolved Oxygen:

Nantucket Harbor is relatively isothermic, with little stratification of temperature between top and bottom. The harbor does warm faster in the spring, and cool faster in the fall, when compared to the sound. This is because it's total volume is less than that of the sound, and more rapidly affected by sidereal conditions. Also because of this, for short periods in the spring, surface temperatures may be slightly warmer; and then slightly cooler conversely as winter sets in. A mild turnover may occur following extreme winters where the surface of the harbor has been covered with ice. The magnitude of the turnover will depend on the severity of the winter, the duration and thickness of the ice. Cooler water will sink, driving up bottom waters, rich with nutrients to the surface. More common on deep lakes, the result is a temporary isothermic condition, breaking up the normal stratification. This is not the case with Nantucket Harbor which is relatively shallow, and well mixed by wind and tidal action.

There was a short period of ice in January of 2005, but it only lasted a couple of weeks. Temperature in this harbor is more relevant to biotic and anaerobic conditions. Where the metabolism of the fauna, the nutrient requirements of the flora, and the dissolved oxygen levels required, to avoid nutrient recycling are most the prevalent issues. The northern bay scallop for example exist in a period of cessation under 7º C, and spawn at temperatures around 22º C. Temperatures above 26º C for extended periods will increase the metabolic rate of these animals resulting in stress, which may bring about premature death.

Higher temperatures will also decrease the solubility of oxygen in water. Dissolved oxygen is lowered by this process, it is further lowered by the process known as biological oxygen demand, generated from respiration and the consumption of oxygen by anaerobic bacteria. Dissolved oxygen levels above 5 mg/l are a desirable condition for most aquatic species. Some species have a wide range of tolerances and may not be stressed until D.O. levels drop below 3 mg/l. Anoxic conditions exist when D.O. levels drop to 1 mg/l and below. Most fish, shellfish, and benthic organisms can not survive anoxic conditions for any length of time. A eutrophic state will also begin to occur as nutrients are released from soils during anoxic events, and nitrogen is recycled into the water column. The resultant affect of these conditions are the blooms of phytoplankton, epiphytic and macro algae; which eventually die increasing nutrients, decreasing oxygen, and decreasing habitat (eel grass). The summer of 2005 sampling rounds showed no temperatures above 26º C, very few hypoxic events, and no anoxic events.

Figure 1: Average Temperatures 2005

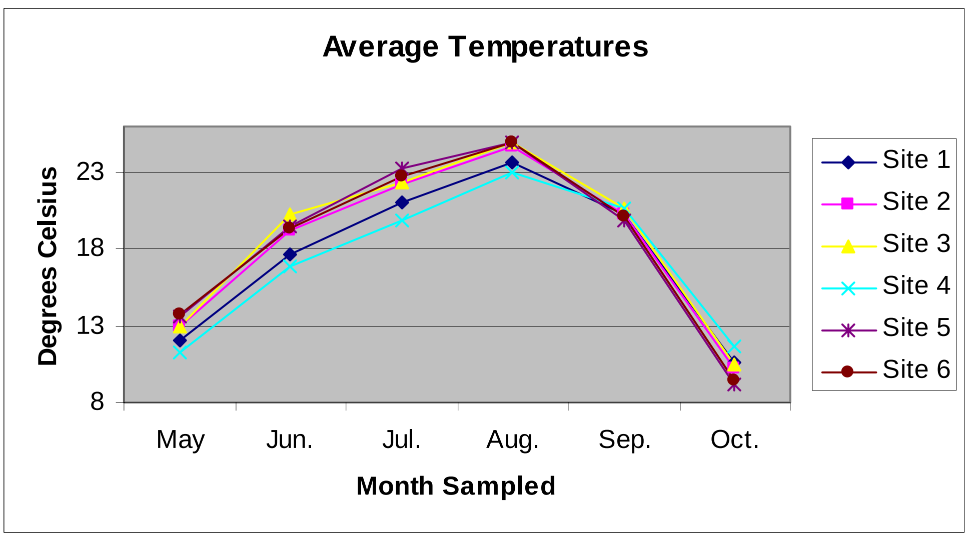
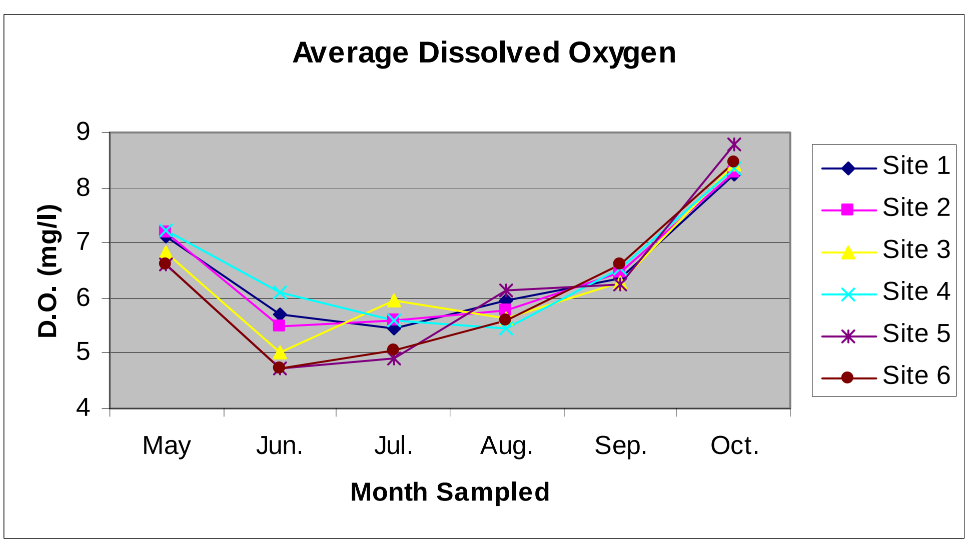


Figure 2: Average Dissolved Oxygen 2005

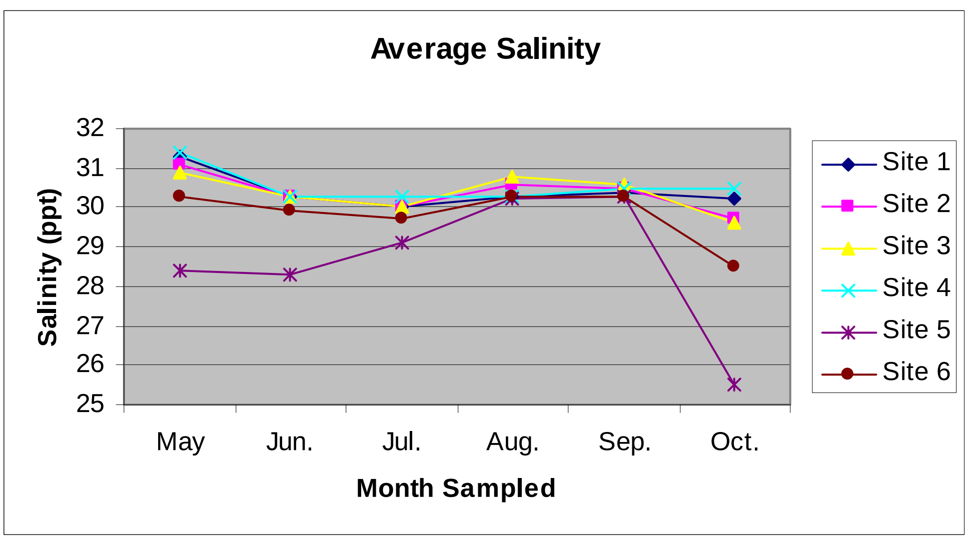


Salinity:

Average salinity in Nantucket Harbor is usually around 30 ppt (parts per thousand), average salinity in the open ocean is closer to 32 ppt. Salinity is important with respects to stratification, and biodiversity. As previously discussed the harbor is well mixed, the only area of exception to this is Polpis Harbor. Because of the large amount of runoff occurring in a relatively small and enclosed area, the salinity gradients in Polpis vary widely from the open harbor. Stratification does occur here, and surface salinities have been measured as low as 24 ppt. Though relatively shallow, the difference between top and bottom may be as much as 6 ppt. Generally this occurs in Polpis West, as this is where most of the fresh water input occurs. Salinity and temperature stratifications may adversely affect dissolved oxygen concentrations.

Different species of aquatic animals often require different salinities at different stages in their life cycles. As such many of these species can sustain variations of salinity ranges. This is best done as adults, however as juveniles, and as larvae, many species have definite salinity requirements. For example winter flounder in their early life cycle prefer salinities around 4 ppt., and herring require almost completely fresh water; as do many anadromous fish species. Oysters may live in salinities as low as 5 ppt., but other shellfish such as bay scallops, have salinity requirements that are much higher (25 ppt for normal development). Further, the larvae of bay scallops can not survive a drop in salinity below 28 ppt.

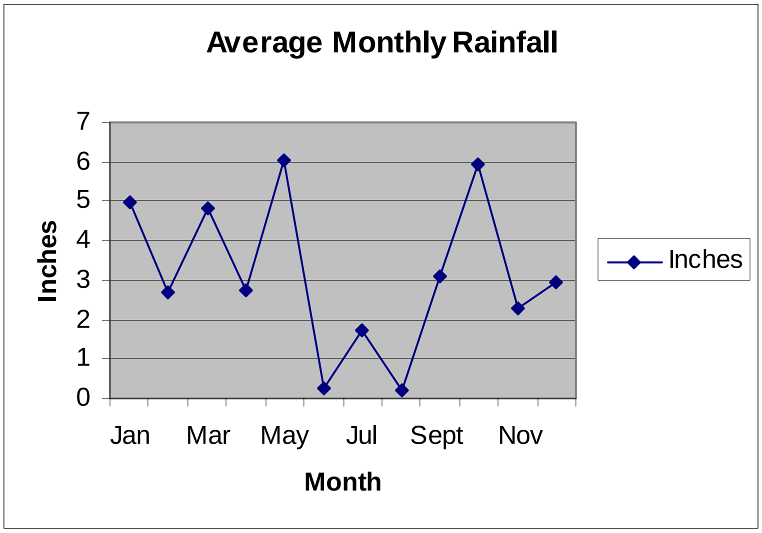
Figure 3: Average Salinity 2005



Rainfall:

Rainfall data corresponds well with salinities in Polpis, where June, July, and August were the driest months; salinities were also the highest (Figure 4). Rainfall also corresponds to nutrient loading, which will be discussed later in the section on nutrients, and the section on streams.

Figure 4: Average Monthly Rainfall 2005



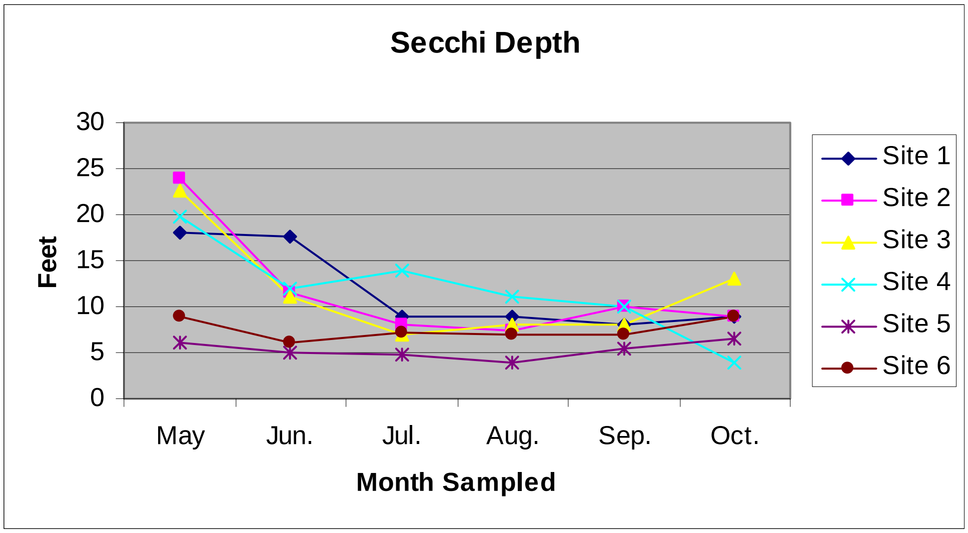
Secchi Depth:

Secchi depth is an approximate measurement of light penetration into the vertical water column. The recorded depth is roughly half the depth that sunlight will reach below the surface of the water. Below this depth photosynthesis is not possible, so a record of this information will provide a rough estimate of potential eel grass habitat. Water transparency is also largely a factor of phytoplankton production, as such it is an indicator of nutrients available in the water column. Generally there are two periods of maximum water clarity prior to and following two major blooms of phytoplankton. Usually these occur at the end of the spring, and just before the winter as water temperatures warm and cool dictating a change in phytoplankton communities.

The microscopic algae diatom, make up the base of primary production in the marine ecosystem. They provide the base of a food web upon which all other marine animals exist, and are normally the dominant species. However, if there is an excessive amount of nutrients and fresh water in a system, the development of a dinoflagellate community may evolve. In 2005 Nantucket experienced a “Red Tide“, the toxic and potentially lethal dinoflagellate *Alexandrium tamerense* closed shellfish beds from 6/2 to 7/5. This was the first known incident for Nantucket, which participates in phytoplankton monitoring for the Division of Marine Fisheries.

Secchi depths were extremely high in May when harbor sampling began for 2005. Sites 5 and 6 are shallow water sites, and do not necessarily reflect secchi depth. When harbor sampling was discontinued for 2005 secchi depths were still low, and are a reflection of water temperatures at that time; which were still relatively warm allowing for continued phytoplankton blooms. These low secchi depths at the end of October also reflect high nutrient availability; which is a result of loading from the watershed, loading from the atmosphere, and internal recycling. At this time the sound was experiencing the lowest secchi depths for all stations, and the highest temperatures. This, along with the occurrence of the red tide which came from northern waters, may be an indication that Nantucket Sound is also experiencing the beginning of a eutrophic condition.

Figure 5: Secchi Depth 2005



Nutrients:

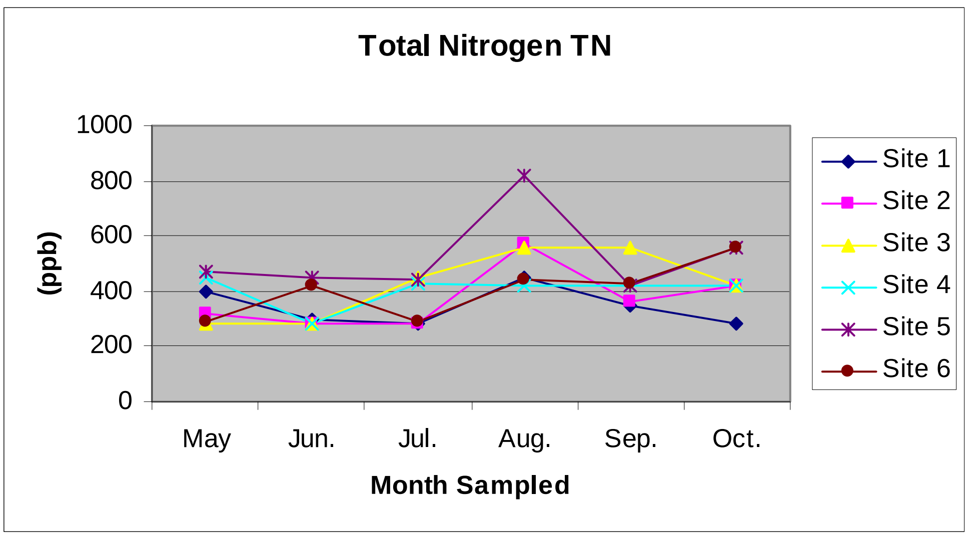
Nitrogen:

Nitrogen is the limiting nutrient in marine ecosystems, the quantity of which will dictate the health of any particular water body. Nitrogen is accumulating in Nantucket Harbor, and because of its shape, the effects of nitrogen are more prevalent in some areas than others. Total nitrogen includes both organic and inorganic components, ammonia or NH3 is the only component (Below Reportable Limit) in Nantucket Harbor (Appendix A). The lobes of Polpis and the various bends in the three major basins, have the capacity because of circulation patterns to trap nitrogen, and exhibit eutrophic conditions. The Department of Environmental Protection for Massachusetts uses some standard classifications based on nitrogen thresholds to describe the health of many marine ecosystems. Nantucket Harbor falls between the SA/SB category, showing some sings of moderate impairment, in some areas during the summer months. These standards can be found in the Estuaries Project Interim Report '03.

Most nitrogen values for Nantucket Harbor waters range between 300 ppb to 500 ppb for most of the summer months sampled. This indicates good/fair water quality, and a mesotrophic state. However Sites 2, 3, and 6 for the months August through October show nitrogen values near to 600 ppb, indicating moderate impairment. Further Site 5, Polpis West recorded total nitrogen at 820 ppb in August indicating severe degradation, and a hyper-eutrophic state. If these conditions persist, and these episodic events continue to occur with longer duration, many parts of Nantucket Harbor may enter into an impaired state.

Once severely degraded conditions have been attained, water bodies become extremely difficult to restore. A change in animal and plant communities may exist for long periods of time, a condition which in some towns appears to be permanent. Fortunately Nantucket Harbor is still in good to fair condition, but phytoplankton blooms are regularly occurring, and macro algae beds of Polysiphona, Grasscilaria, Cladophera, and others are becoming more prevalent. These macro algae are the result of increased nutrients, and can smother eel grass beds resulting in a loss of habitat for preferred marine organisms. Bacteria levels monitored by the Division of Marine Fisheries, maintain shellfish closures in the lower harbor; and these areas are increasing in size. The Town of Nantucket assisted by the state is taking measures to correct this decline, and hopefully we are ahead of the problem.

Figure 6: Total Nitrogen 2005



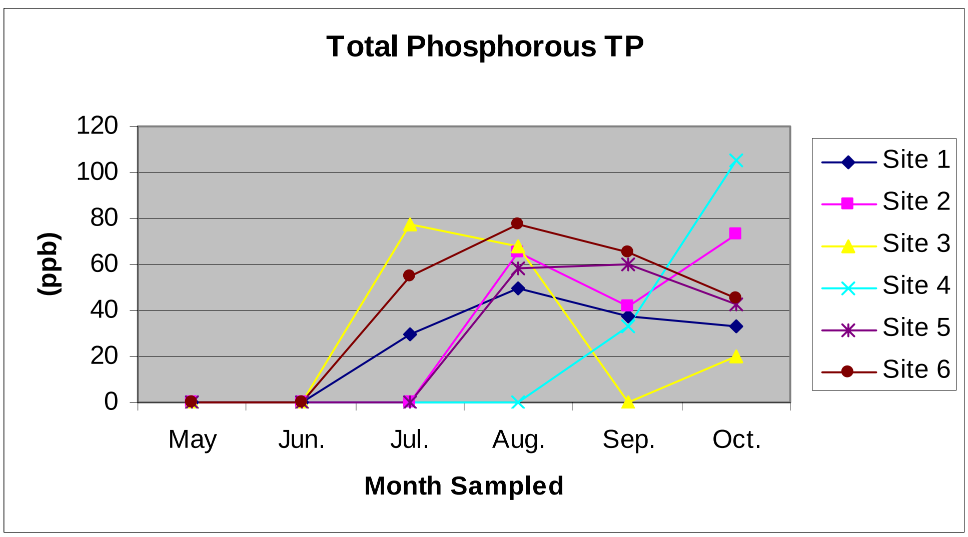
Phosphorous:

Phosphorous is a limiting nutrient in fresh water, but it is of relative concern to the marine ecosystem, because in over abundance it can affect the type of phytoplankton species, and pond weed that will be dominant in any system. The level of total phosphorous becomes a problem when values around 50 ppb become prevalent. This level would indicate a eutrophic condition, it would be associated with excessive undesirable plant growth, and anoxic events. A value of 25 ppb TP would be representative of a good/fair mesotrophic system with corresponding nitrogen values around 400 ppb. Phosphorous, like nitrogen is naturally occurring, and would be expected at certain levels based on the geology of any given area.

However, the influx of phosphorous from fertilizers, detergents, and septic systems will load a system, and upset the preferred balance. Usually the result is a preponderance of blue/green algae, which through its life cycle processes can choke a system; marine or fresh. Total phosphorous was consistently above 25 ppb for many monitoring sites throughout the summer. Many sites recorded levels above 50 ppb, suggesting an enriched condition for the harbor. Polpis sites were high as expected. However, Site 4 recorded an extremely high 105 ppb in October. This was not expected and may be the result of phosphorous increasing in the sound from combined anthropogenic uses from other communities.

Loading usually begins in the spring, and lasts through to the end of the summer, when levels are highest. The decline of phosphorous in the head of harbor in September may be due to a decline in precipitation (Figure 4, Appendix E). Phosphorous was nearly non existent in May and June, and only showed up high at two sites in July. This is most likely related to the seasonal fluctuation of residents on Island, which does not peak until late June.

Figure 7: Total Phosphorous 2005



Streams:

The streams that enter into the head, and middle harbor areas are monitored to get an estimate on the amount of nutrient loading that is occurring in that watershed (Map #2). The sampling is conducted monthly, and so may not accurately reflect a total maximum daily load. However when cross referenced with monthly precipitation, the amount of total nitrogen, and total phosphorous in kg/day is a relative factor in loading which needs to be monitored.

Stream data located in (Appendix C) shows that ground water temperatures are often cooler throughout the summer than harbor temperatures. Dissolved oxygen as expected is also lower. Water samples are taken on an ebb tide, and during dry months high salinities may be observed in Stream 1. Also interesting was the ammonia level taken at Stream 1 on August 9th, 1,610 ppb; as yet unexplainable. Stream 6c was added this year, because Polpis West, Site 5 (the most degraded sampling site) receives most of the run off from this area of the watershed. High levels of total nitrogen and total phosphorous were detected here on two separate occasions.

Stream 1 and 4 seem to be most affected by early rainfall, with respects to TN loading. For TP, Streams 1, 4, and 6a appear to be most affected by spring precipitation through May. Stream 8, had high TP loading for all six sampling rounds, and may be receiving a constant load from anthropogenic uses in it's direct watershed area. Streams 2,3,5, and 7 showed the least amount of loading for all six sampling rounds, and seem to be least affected by their watersheds. As yet these areas are outside the Town Sewer District, however there are plans to inspect all septic systems in the harbor watershed in the near future (Nantucket Health Department).

Figure 8: Total Nitrogen Loading 2005

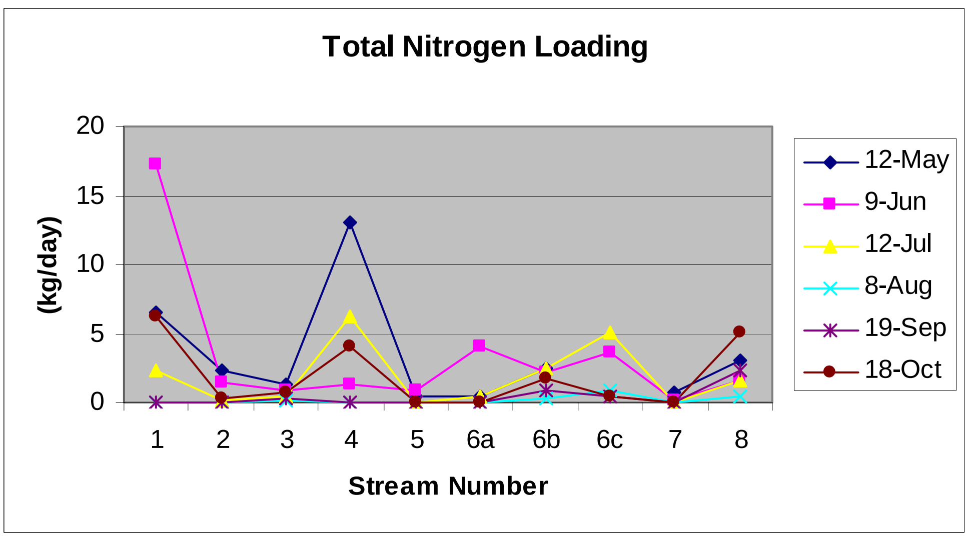
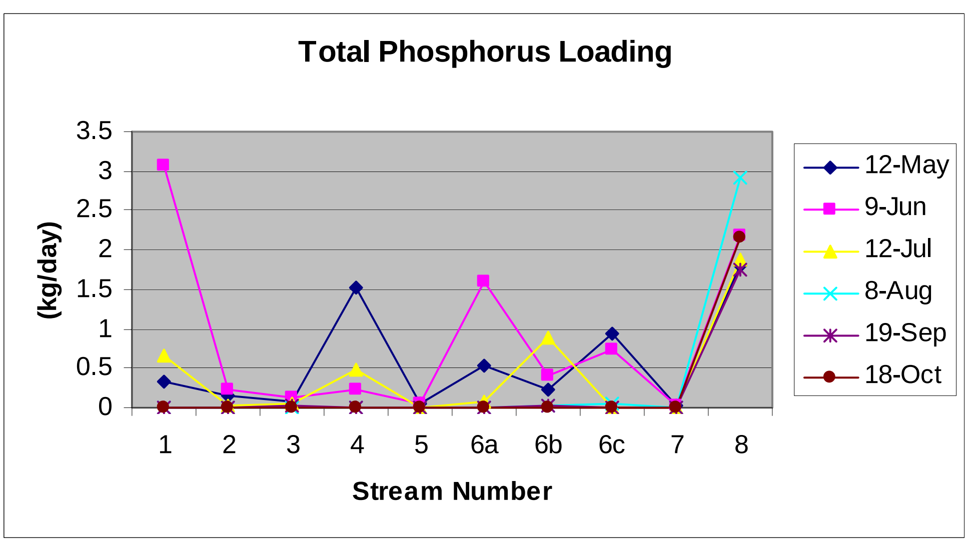


Figure 9: Total Phosphorous Loading 2005



Conclusion:

Nantucket Harbor remains in good/fair condition, and maintains the capacity to produce an abundant supply of recreationally and commercially harvestable shellfish and finfish. The aesthetic, and intrinsic value this natural resource holds can be seen in the property values in and around its watershed. The State and Town have undertaken great means to protect the integrity of the harbor. If managed well the viability of the harbor will remain intact. Upcoming reports and conclusions from the Urban Harbor Institute, Massachusetts Estuaries Project, and Earth Tech, will provide the Town with a new Harbor Plan, a total maximum daily load threshold management plan (TMDL), and an island wide septage management plan. The Marine Dept. will continue it’s sampling regime, and will likely add chlorophyll to it’s quantitative analysis, and macro algae coverage to aid in a qualitative analysis. Hopefully these efforts will ensure the safety of Nantucket Harbor for years to come.

Appendix A

Nantucket Harbor Physical and Chemical Data 2005

Site 1	Mooring Field
Site 2	Quaise Basin
Site 3	Head of Harbor
Site 4	Nantucket Sound
Site 5	Polpis West
Site 6	Polpis East

Temperature ºC

Site 1	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	12.4	18	21.3	23.8	20.4	10.6
3	12.3	17.9	21.3	23.7	20.4	10.6
6	12.1	17.8	21.2	23.7	20.3	10.6
9	11.8	17.6	21.1	23.7	20.3	10.6
12	11.8	17.4	20.9	23.6	20.3	10.7
15	11.7	17.4	20.6	23.5	20.3	10.7
18	11.7	17.3	20.6	23.4	20.3	10.7

Site 2	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	13.3	19.3	22.3	24.9	20.3	10.2
3	13.3	19.3	22.3	24.9	20.3	10.3
6	13.2	19.3	22.2	24.8	20.2	10.2
9	13.2	19.3	22.3	24.8	20.2	10.2
12	13.1	19.3	22.2	24.8	20.2	10.2
15	13.1	19.3	22.2	24.7	20.2	10.2
18	13	19.2	22.2	24.6	20.2	10.2
21	12.9	18.9	22.1	24.6	20.2	10.2
24	12.7	18.5	22.1	24.5	20.2	10.5

Site 3	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	13	20.1	22.5	25	20.7	10.4
3	13.1	20.2	22.5	25	20.7	10.4
6	13.2	20.2	22.4	25	20.7	10.5
9	13.2	20.3	22.4	24.9	20.7	10.5
12	13.2	20.3	22.3	24.9	20.6	10.5
15	13.2	20.2	22.3	24.8	20.6	10.5
18	13.2	20.2	22.3	24.7	20.6	10.5
21	13.2	20.2	22.2	24.7	20.5	10.4

Site 4	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	11.3	16.9	20.4	23.1	20.8	11.7
3	11.4	16.9	20.3	23.1	20.7	11.7
6	11.2	16.9	20.1	23.1	20.7	11.7
9	11.1	16.9	19.8	23	20.7	11.7
12	11.1	16.9	19.5	22.8	20.7	11.7
15	11.1	16.9	19.8	22.8	20.7	11.7
18	11.1	16.9	19.5	22.8	20.7	11.7

Site 5	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	13.5	19.4	23.3	25	19.9	9.3
3	13.7	19.6	23.3	24.9	19.9	9
6	13.5	19.5	23.3	24.8	19.9	9.4

Site 6	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	14.2	18.9	22.9	25.1	20.2	9.4
3	14.1	19.6	22.9	25	20.1	9.4
6	13.4	19.5	22.6	25	20.1	9.4
9	13.3	19.5	22.5	25	20	9.5

Dissolved Oxygen mg/l

Site 1	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	7.09	5.69	5.53	6.02	6.46	8.25
3	7.05	5.66	5.42	6	6.31	8.23
6	7.13	5.66	5.44	5.99	6.34	8.25
9	7.15	5.76	5.48	5.98	6.35	8.25
12	7.14	5.71	5.43	5.95	6.31	8.26
15	7.13	5.68	5.29	5.91	6.33	8.26
18	7.15	5.69	5.52	5.81	6.32	8.28

Site 2	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	7.24	5.66	5.44	5.95	6.56	8.24
3	7.22	5.74	5.56	5.91	6.48	8.25
6	7.24	5.73	5.74	5.91	6.48	8.24
9	7.21	5.69	5.82	5.88	6.47	8.26
12	7.25	5.68	5.78	5.91	6.44	8.25
15	7.18	5.63	5.75	5.92	6.46	8.35
18	7.21	5.61	5.67	5.67	6.43	8.35
21	7.12	5.15	5.44	5.47	6.45	8.24
24	7.05	4.54	5.19	5.32	6.36	8.24

Site 3	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	6.96	5.41	1/6/1900	5.71	6.34	8.48
3	6.98	5.39	6.14	5.78	6.35	8.39
6	6.97	5.39	6.22	5.78	6.35	8.4
9	6.94	4.98	6.22	5.76	6.37	8.42
12	6.99	4.9	6.12	5.71	6.34	8.38
15	7.02	4.9	6.14	5.56	6.35	8.44
18	6.34	4.65	5.94	5.43	6.21	8.45
21	6.33	4.63	4.65	5.28	5.95	8.45

Site 4	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	7.29	6.07	5.22	5.61	6.59	8.41
3	7.23	6.11	5.18	5.52	6.54	8.33
6	7.26	6.12	5.69	5.53	6.5	8.38
9	7.24	6.09	5.63	5.46	6.52	8.36
12	7.23	6.1	5.67	5.38	6.51	8.32
15	7.24	6.11	5.91	5.29	6.53	8.35
18	7.22	6.1	5.92	5.29	6.54	8.31

Site 5	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	6.61	4.79	4.94	5.67	6.17	8.74
3	6.69	4.72	4.93	5.78	6.09	8.81
6	6.51	4.67	4.82	7.02	6.53	8.79

Site 6	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	6.62	4.94	5.37	5.59	6.81	8.48
3	6.63	4.86	5.29	5.57	6.73	8.46
6	6.55	4.9	5.52	5.61	6.48	8.44
9	6.65	4.25	3.99	5.66	6.42	8.44

Salinity ppt.

Site 1	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	31.3	30.1	29.9	30.3	30.4	30.1
3	31.3	30.3	29.9	30.3	30.4	30.1
6	31.3	30.4	30	30.3	30.4	30.1
9	31.3	30.4	30.1	30.4	30.4	30.2
12	31.3	30.4	30.2	30.3	30.4	30.2
15	31.3	30.4	30.1	30.3	30.4	30.2
18	31.3	30.4	30.1	30.3	30.4	30.2

Site 2	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	30.9	30.3	29.8	30.6	30.5	29.6
3	31	30.3	29.8	30.6	30.5	29.6
6	31	30.3	30	30.6	30.5	29.6
9	31.1	30.3	30	30.7	30.5	29.6
12	31.1	30.3	30	30.7	30.5	29.6
15	31.1	30.3	30.1	30.7	30.5	29.6
18	31.1	30.4	30.1	30.6	30.5	29.7
21	31.1	30.4	30.1	30.6	30.5	29.9
24	31.1	30.4	30	30.6	30.5	29.9

Site 3	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	30.9	30.4	30	30.8	30.5	29.6
3	30.9	30.3	30	30.8	30.5	29.6
6	30.9	30.3	30	30.8	30.5	29.6
9	30.9	30.2	30	30.8	30.6	29.6
12	30.9	30.2	30	30.8	30.6	29.6
15	30.9	30.2	30.1	30.8	30.6	29.6
18	30.9	30.2	30.1	30.7	30.6	29.6
21	30.9	30.2	30.1	30.8	30.5	29.6

Site 4	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	31.4	30.3	30.2	30.3	30.5	30.5
3	31.4	30.3	30.2	30.3	30.5	30.5
6	31.4	30.3	30.5	30.3	30.5	30.5
9	31.4	30.3	30.3	30.3	30.5	30.5
12	31.4	30.3	30.2	30.3	30.5	30.5
15	31.3	30.3	30.2	30.3	30.5	30.5
18	31.3	30.3	30.2	30.3	30.5	30.5

Site 5	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	24.6	27.7	29.1	30.2	30.3	23.9
3	30.1	29.5	29.1	30.2	30.3	24.3
6	30.4	27.7	29.1	30.2	30.3	28.3

Site 6	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
0	30	29.6	29.6	30.2	30.3	28.4
3	30.1	29.8	29.7	30.2	30.3	28.4
6	30.5	30	29.7	30.3	30.3	28.5
9	30.6	30	29.7	30.3	30.3	28.8

Secchi ft.

	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
Site 1	18	17.7	9	9	8	9
Site 2	24	11.5	8	7.5	10	9
Site 3	22.6	11	7	8	8	13
Site 4	19.7	12	14	11	10	4
Site 5	6	5	4.7	4	5.5	6.5
Site 6	9	6	7.1	7	7	9

Nitrate NO3 ppb

	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
Site 1	120	20	BRL	30	BRL	BRL
Site 2	40	BRL	BRL	10	10	BRL
Site 3	BRL	BRL	30	BRL	BRL	BRL
Site 4	30	BRL	10	BRL	BRL	BRL
Site 5	50	30	20	120	BRL	BRL
Site 6	10	BRL	10	20	10	BRL

Organic Nitrogen TKN ppb

	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
Site 1	280	280	280	420	350	280
Site 2	280	280	280	560	350	420
Site 3	280	280	420	560	560	420
Site 4	420	280	420	420	420	420
Site 5	420	420	420	700	420	560
Site 6	280	420	280	420	420	560

Total Nitrogen TN ppb

	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
Site 1	400	300	280	450	350	280
Site 2	320	280	280	570	360	420
Site 3	280	280	450	560	560	420
Site 4	450	280	430	420	420	420
Site 5	470	450	440	820	420	560
Site 6	290	420	290	440	430	560

Amonia NH3 ppb

	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
Site 1	BRL	BRL	BRL	BRL	BRL	BRL
Site 2	BRL	BRL	BRL	BRL	BRL	BRL
Site 3	BRL	BRL	BRL	BRL	BRL	BRL
Site 4	BRL	BRL	BRL	BRL	BRL	BRL
Site 5	BRL	BRL	BRL	BRL	BRL	BRL
Site 6	BRL	BRL	BRL	BRL	BRL	BRL

Total Phosphorous TP ppb

	5/18/2005	6/16/2005	7/13/2005	8/11/2005	9/26/2005	10/27/2005
Site 1	BRL	BRL	30	50	37	33
Site 2	BRL	BRL	BRL	65	42	73
Site 3	BRL	BRL	77	68	BRL	20
Site 4	BRL	BRL	BRL	BRL	33	105
Site 5	BRL	BRL	BRL	58	60	43
Site 6	BRL	BRL	55	77	65	45

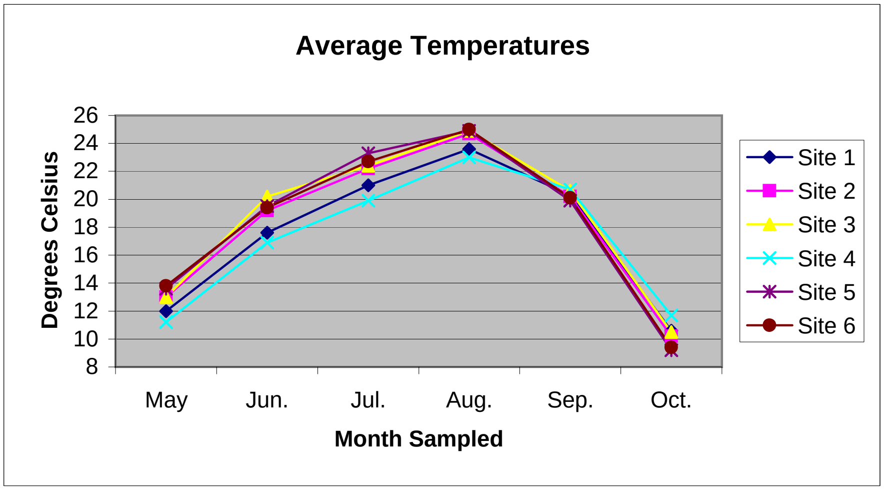
BRL = below reportable limit

Appendix B

Nantucket Harbor Average Physical and Chemical Paramaters 2005

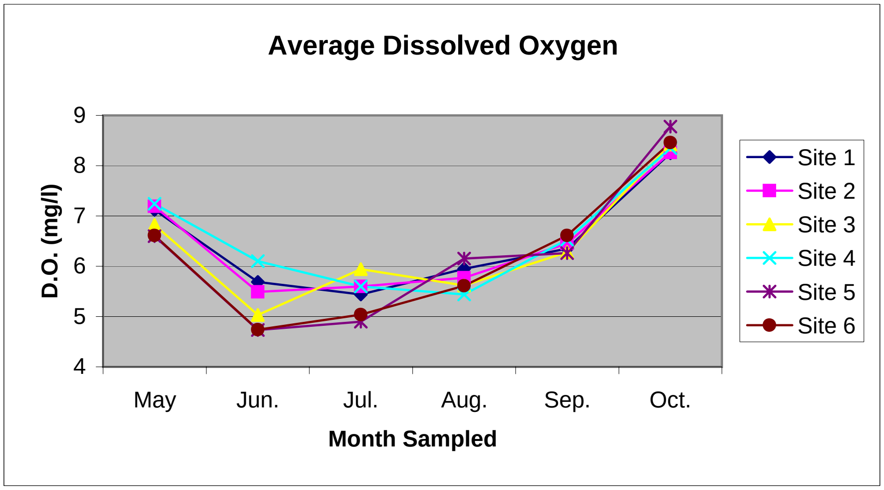
Average Temperature (ºC)

Site	May	Jun.	Jul.	Aug.	Sep.	Oct.
1	12	17.6	21	23.6	20.3	10.6
2	13	19.2	22.2	24.7	20.2	10.2
3	13	20.2	22.4	24.9	20.6	10.5
4	11.2	16.9	19.9	23	20.7	11.7
5	13.6	19.5	23.3	24.9	19.9	9.2
6	13.8	19.4	22.7	25	20.1	9.4



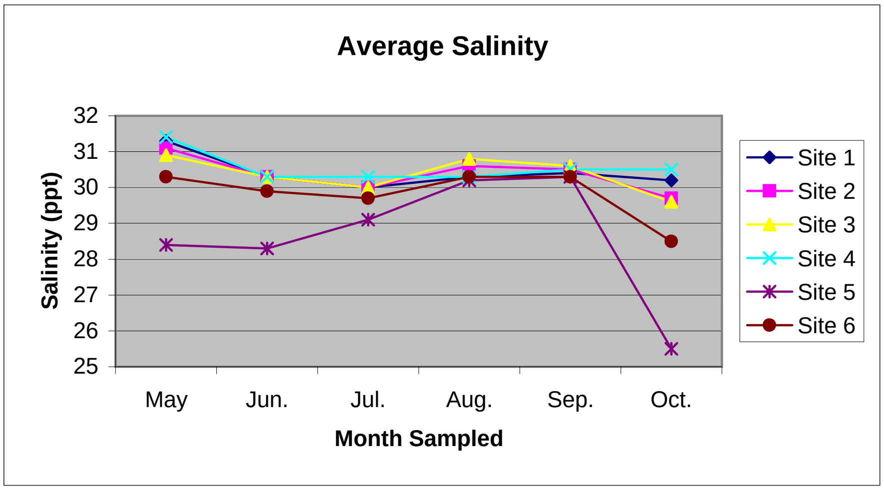
Average Dissolved Oxygen (mg/l)

Site	May	Jun.	Jul.	Aug.	Sep.	Oct.
1	7.12	5.69	5.44	5.95	6.35	8.25
2	7.19	5.49	5.6	5.77	6.45	8.26
3	6.82	5.03	5.94	5.62	6.28	8.42
4	7.24	6.1	5.6	5.44	6.53	8.35
5	6.6	4.73	4.9	6.15	6.26	8.78
6	6.61	4.74	5.04	5.61	6.61	8.46



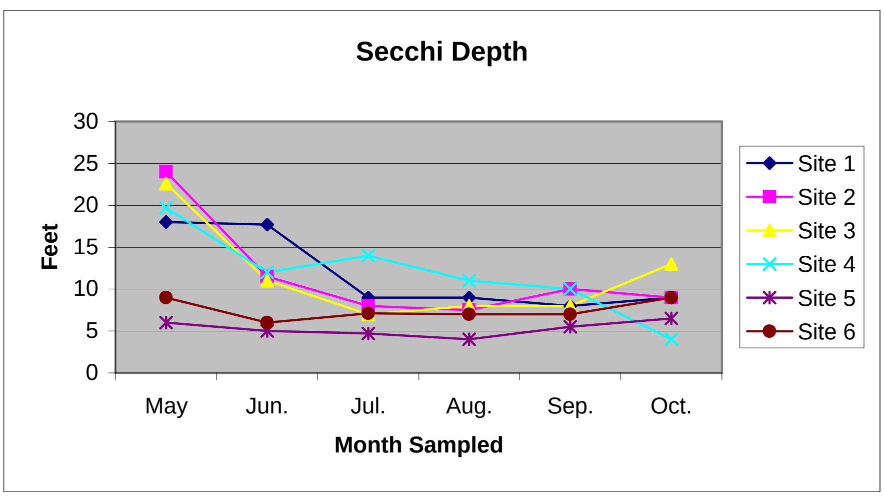
Average Salinity (ppt)

Site	May	Jun.	Jul.	Aug.	Sep.	Oct.
1	31.3	30.3	30	30.3	30.4	30.2
2	31.1	30.3	30	30.6	30.5	29.7
3	30.9	30.3	30	30.8	30.6	29.6
4	31.4	30.3	30.3	30.3	30.5	30.5
5	28.4	28.3	29.1	30.2	30.3	25.5
6	30.3	29.9	29.7	30.3	30.3	28.5



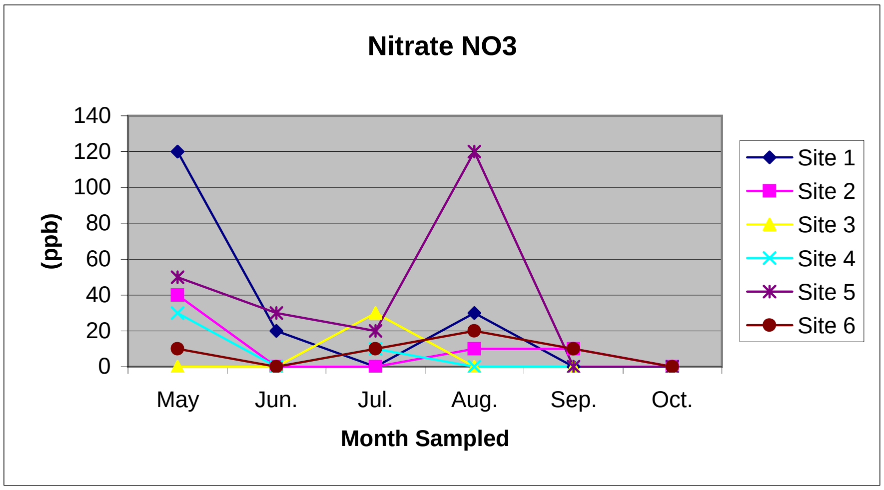
Secchi Depth

Site	May	Jun.	Jul.	Aug.	Sep.	Oct.
1	18	17.7	9	9	8	9
2	24	11.5	8	7.5	10	9
3	22.6	11	7	8	8	13
4	19.7	12	14	11	10	4
5	6	5	4.7	4	5.5	6.5
6	9	6	7.1	7	7	9



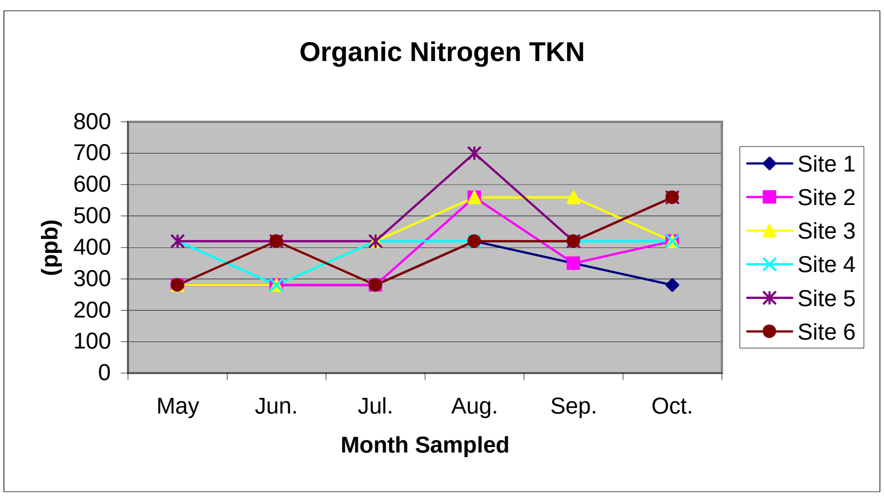
Nitrate NO3 (ppb)

	May	Jun.	Jul.	Aug.	Sep.	Oct.
Site 1	120	20	BRL	30	BRL	BRL
Site 2	40	BRL	BRL	10	10	BRL
Site 3	BRL	BRL	30	BRL	BRL	BRL
Site 4	30	BRL	10	BRL	BRL	BRL
Site 5	50	30	20	120	BRL	BRL
Site 6	10	BRL	10	20	10	BRL



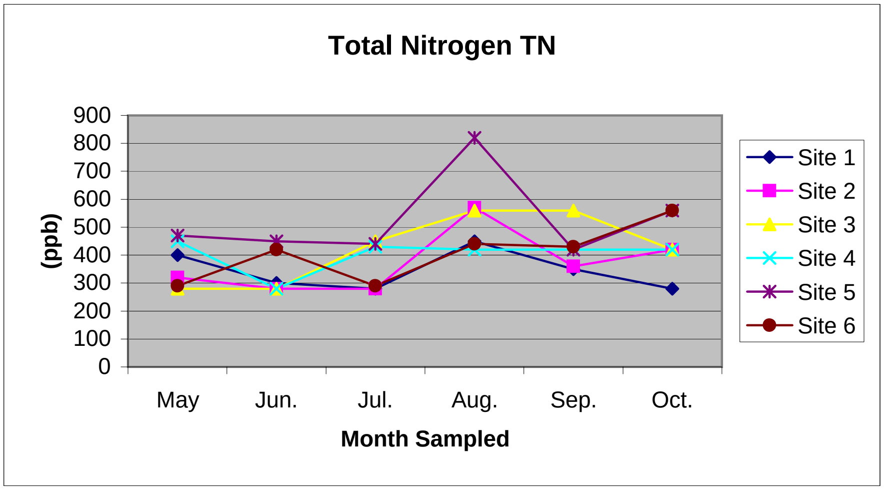
Organic Nitrogen TKN (ppb)

	May	Jun.	Jul.	Aug.	Sep.	Oct.
Site 1	280	280	280	420	350	280
Site 2	280	280	280	560	350	420
Site 3	280	280	420	560	560	420
Site 4	420	280	420	420	420	420
Site 5	420	420	420	700	420	560
Site 6	280	420	280	420	420	560



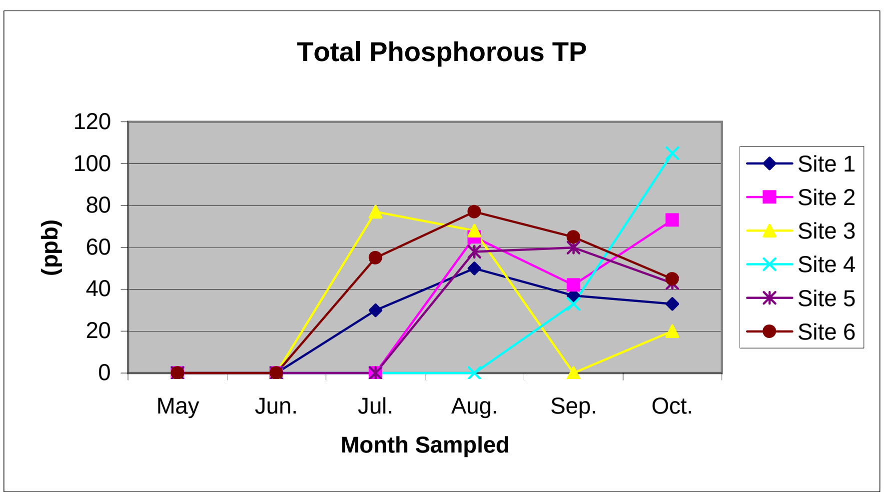
Total Nitrogen TN (ppb)

	May	Jun.	Jul.	Aug.	Sep.	Oct.
Site 1	400	300	280	450	350	280
Site 2	320	280	280	570	360	420
Site 3	280	280	450	560	560	420
Site 4	450	280	430	420	420	420
Site 5	470	450	440	820	420	560
Site 6	290	420	290	440	430	560



Total Phosphorous TP (ppb)

	May	Jun.	Jul.	Aug.	Sep.	Oct.
Site 1	BRL	BRL	30	50	37	33
Site 2	BRL	BRL	BRL	65	42	73
Site 3	BRL	BRL	77	68	BRL	20
Site 4	BRL	BRL	BRL	BRL	33	105
Site 5	BRL	BRL	BRL	58	60	43
Site 6	BRL	BRL	55	77	65	45



Appendix C

Stream Physical and Chemical Data 2005

1: flows into the Head of the Harbor
2: flows into Medouie Creek
3: flows into Polpis East
4: flows into Polpis East, draining Cranberry Bog
5: flows into Polpis West, draining swamp near cemetary
6a: flows into Polpis West
6b: flows into Polpis West
6c: flows into Polpis West, draining Duck Pond
7: flows into Quaise
8: flows into Fulling Mill Brook, next to Life Saving Museum

Temperature ºC

Stream	5/12/2005	6/9/2005	7/12/2005	8/9/2005	9/19/2005	10/18/2005
1	10.9	16.8	18.2	19.3	19.2	13.4
2	11.5	17.3	17.9	ns	ns	13.1
3	12.7	18.9	18.8	18.2	17	13.2
4	12.5	18.7	20.1	20.5	18.8	12.4
5	10.3	15.4	ns	ns	ns	12.8
6a	12.8	17.6	19.8	ns	ns	12.5
6b	11.5	17.4	20	20	17.2	12.3
6c	ns	19.9	20.3	23.8	18.1	12.7
7	12.1	18.6	20.1	ns	ns	13
8	12.1	16.3	17.2	15.9	16.1	12.8

Dissolved Oxygen mg/l

Stream	5/12/2005	6/9/2005	7/12/2005	8/9/2005	9/19/2005	10/18/2005
1	4.82	4.91	5.37	1.56	0.84	5.56
2	3.67	0.96	0.68	ns	ns	2.28
3	6.54	3.63	2.54	3.22	3.27	4.54
4	4.11	2.45	2.22	1.36	2.5	5.11
5	2.68	0.47	ns	ns	ns	3.28
6a	3.51	1.79	1.6	ns	ns	3.56
6b	6.41	3.38	2.56	4.85	5.21	6.31
6c	ns	5.93	5.23	5.74	3.49	8.52
7	2.94	0.53	0.64	ns	ns	1.65
8	5.18	4.42	3.48	5.69	4.39	5.42

Salinity ppt.

Stream	5/12/2005	6/9/2005	7/12/2005	8/9/2005	9/19/2005	10/18/2005
1	0.1	0.1	0.1	23.7	24.7	0.1
2	0.1	0.1	0.1	ns	ns	0.1
3	0.1	0.1	0.1	0.1	0.1	0.1
4	0	0.1	0.1	0	0.1	0.1
5	0	0.1	ns	ns	ns	0.1
6a	0.1	0.1	0.1	ns	ns	0.1
6b	0	0.1	0	0	0	0
6c	ns	0.1	0.1	0	0.1	0
7	0.1	0.1	0.1	ns	ns	0.1
8	1.9	1.5	0.8	0.4	2.8	22.2

Conductivity us

Stream	5/12/2005	6/9/2005	7/12/2005	8/9/2005	9/19/2005	10/18/2005
1	102.9	128	141.1	33.16ms	34.93ms	228.9
2	93.5	116.4	126.8	ns	ns	224.8
3	80.5	99.3	105	90.9	120.9	108.2
4	71.4	92.1	98.7	76.4	178.9	126.1
5	71.2	101.8	ns	ns	ns	177.1
6a	92	129.1	114.8	ns	ns	95.7
6b	64.3	87.5	21.3	75.5	78.8	66
6c	ns	99.1	110.9	83.4	85.1	70.2
7	85.6	109.8	107.6	ns	ns	120.7
8	2,647	2,412	1,365	633	4,276	24.77ms

Height x Width cm

Stream	5/12/2005	6/9/2005	7/12/2005	8/9/2005	9/19/2005	10/18/2005
1	35 x 50	22 x 80	17 x 37	no flow	no flow	21 x 48
2	15 x 33	14 x 35	6 x 21	no flow	no flow	6 x 27
3	20 x 32	15 x 35	14 x 23	14 x 33	10 x 31	13 x 26
4	65 x 95	60 x 93	52 x 74	no flow	no flow	56 x 82
5	18 x 38	10 x 22	no flow	no flow	no flow	no flow
6a	11 x 28	11 x 26	6 x 17	no flow	no flow	3 x 6
6b	6 x 90	5 x 102	3 x 66	1 x 57	3 x 42	6 x 42
6c	ns	30 x 27	15 x 43	3 x 25	3 x 21	6 x 17
7	25 x 22	no flow	7 x 13	no flow	no flow	no flow
8	46 x 88	41 x 80	47 x 83	40 x 86	40 x 82	66 x 88

Velocity ft./sec.

Stream	5/12/2005	6/9/2005	7/12/2005	8/9/2005	9/19/2005	10/18/2005
1	2.23	3.72	1.69	no flow	no flow	2.79
2	2.79	1.13	0.46	no flow	no flow	1.16
3	1.42	0.98	0.58	0.46	0.46	0.46
4	1.29	no flow	0.82	no flow	no flow	0.39
5	0.36	0.65	no flow	no flow	no flow	no flow
6a	2.22	3.57	1.24	no flow	no flow	0.1
6b	3.92	2.21	3.82	1.55	2.7	6.57
6c	ns	4.29	5.59	6.06	2.23	3.41
7	0.26	no flow	0.36	no flow	no flow	no flow
8	1.39	0.87	0.82	1.21	0.85	max flood avg

Nitrate NO3 ppb

Stream	5/12/2005	6/9/2005	7/12/2005	8/9/2005	9/19/2005	10/18/2005
1	BRL	BRL	BRL	BRL	BRL	BRL
2	BRL	BRL	BRL	ns	ns	BRL
3	50	50	60	20	60	BRL
4	BRL	BRL	BRL	BRL	BRL	BRL
5	BRL	BRL	ns	ns	ns	BRL
6a	BRL	BRL	BRL	ns	ns	BRL
6b	BRL	BRL	BRL	BRL	BRL	BRL
6c	ns	BRL	BRL	BRL	BRL	BRL
7	BRL	ns	BRL	ns	ns	BRL
8	BRL	BRL	BRL	BRL	20	BRL

Organic Nitrogen TKN ppb

Stream	5/12/2005	6/9/2005	7/12/2005	8/9/2005	9/19/2005	10/18/2005
1	630	1,005	840	NR	630	840
2	630	980	1260	ns	ns	770
3	490	560	980	420	630	1,540
4	630	770	770	BRL	910	840
5	630	2,240	ns	ns	ns	770
6a	1190	1,470	1400	ns	ns	630
6b	490	840	980	350	350	350
6c	ns	420	490	490	560	560
7	840	ns	1610	ns	ns	1,400
8	210	210	280	35	280	350

Total Nitrogen TN ppb

Stream	5/12/2005	6/9/2005	7/12/2005	8/9/2005	9/19/2005	10/18/2005
1	630	1,005	840	NR	630	840
2	630	980	1260	ns	ns	770
3	540	610	1040	420	690	1,540
4	630	770	770	<0.5	910	840
5	630	2,240	ns	ns	ns	770
6a	1190	1,470	1400	ns	ns	630
6b	490	840	980	350	350	350
6c	ns	420	490	490	560	560
7	840	ns	1610	ns	ns	1,400
8	210	210	210	35	300	350

Amonia NH3 ppb

Stream	5/12/2005	6/9/2005	7/12/2005	8/9/2005	9/19/2005	10/18/2005
1	BRL	BRL	BRL	1,610	BRL	BRL
2	BRL	BRL	BRL	ns	ns	BRL
3	BRL	BRL	BRL	BRL	BRL	BRL
4	BRL	BRL	BRL	BRL	BRL	BRL
5	BRL	BRL	ns	ns	ns	BRL
6a	BRL	BRL	BRL	ns	ns	BRL
6b	BRL	BRL	BRL	BRL	BRL	BRL
6c	ns	BRL	BRL	BRL	BRL	BRL
7	BRL	ns	BRL	ns	ns	BRL
8	BRL	BRL	BRL	BRL	BRL	BRL

Total Phosphorous TP ppb

Stream	5/12/2005	6/9/2005	7/12/2005	8/9/2005	9/19/2005	10/18/2005
1	31	178	243	BRL	233	BRL
2	42	154	198	ns	ns	BRL
3	27	84	67	BRL	70	30
4	73	128	60	33	88	BRL
5	55	138	ns	ns	ns	BRL
6a	313	613	232	ns	ns	73
6b	42	158	347	22	5	BRL
6c	ns	108	70	8	62	3
7	27	ns	173	ns	ns	50
8	123	280	240	260	225	147

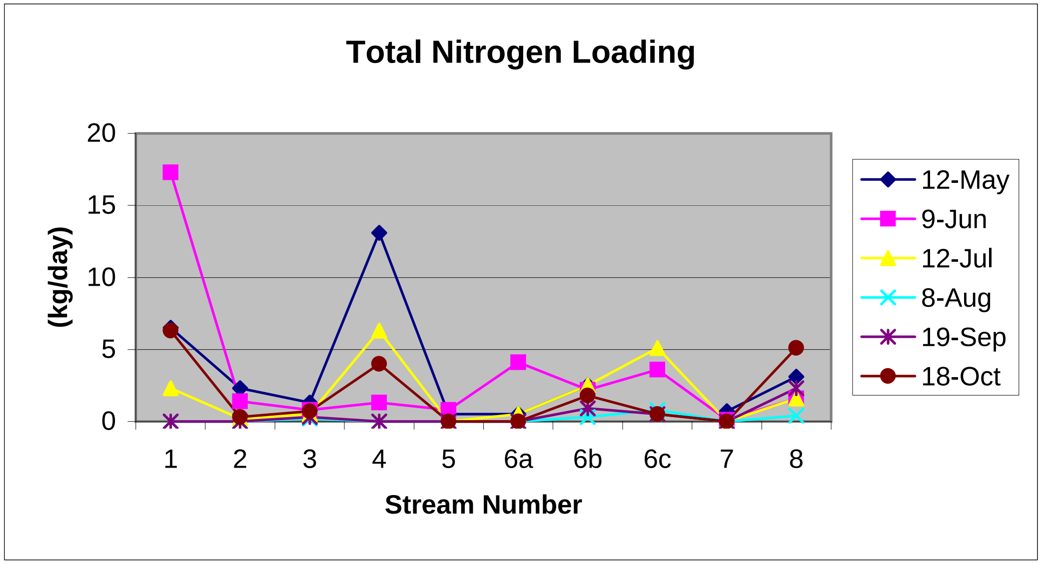
BRL = below reportable limit
NR = not recorded by lab due to insuficient sample size
ns = not sampled, due to lack of water, and or lack of flow
nf = no flow, no water velocity, or movement

Appendix D

Stream Loading 2005

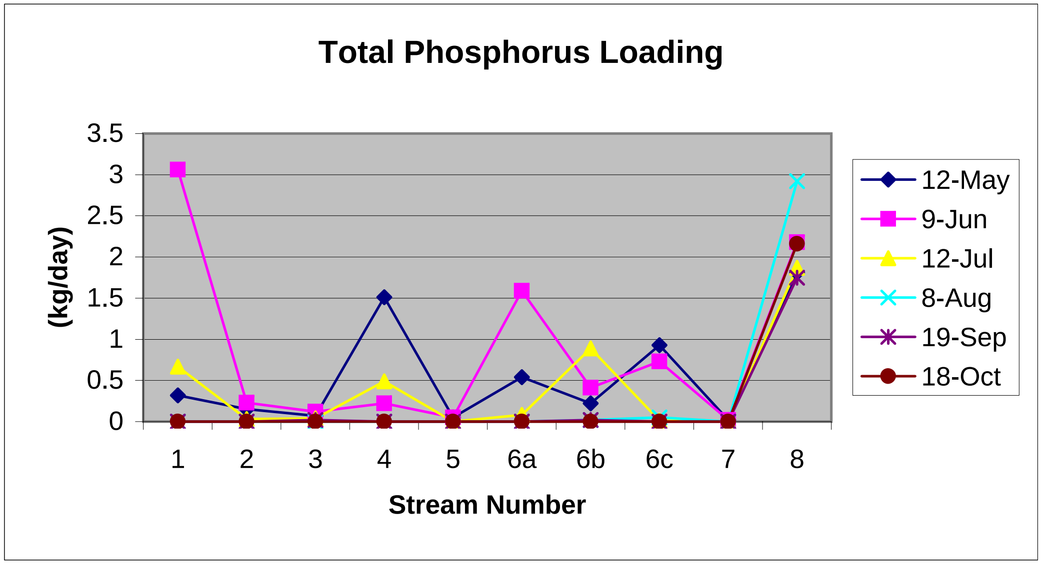
Total Nitrogen Loading (kg/day)

	1	2	3	4	5	6a	6b	6c	7	8
12-May	6.5	2.3	1.3	13.1	0.5	0.5	2.5		0.7	3.1
9-Jun	17.3	1.4	0.8	1.3	0.8	4.1	2.2	3.6	0.1	1.6
12-Jul	2.3	0.2	0.5	6.3	0	0.5	2.5	5.1	0	1.6
8-Aug	0	0	0.2	0	0	0	0.3	0.8	0	0.4
19-Sep	0	0	0.3	0	0	0	0.9	0.5	0	2.3
18-Oct	6.3	0.3	0.7	4	0	0	1.8	0.5	0	5.1



Total Phosphorus Loading (kg/day)

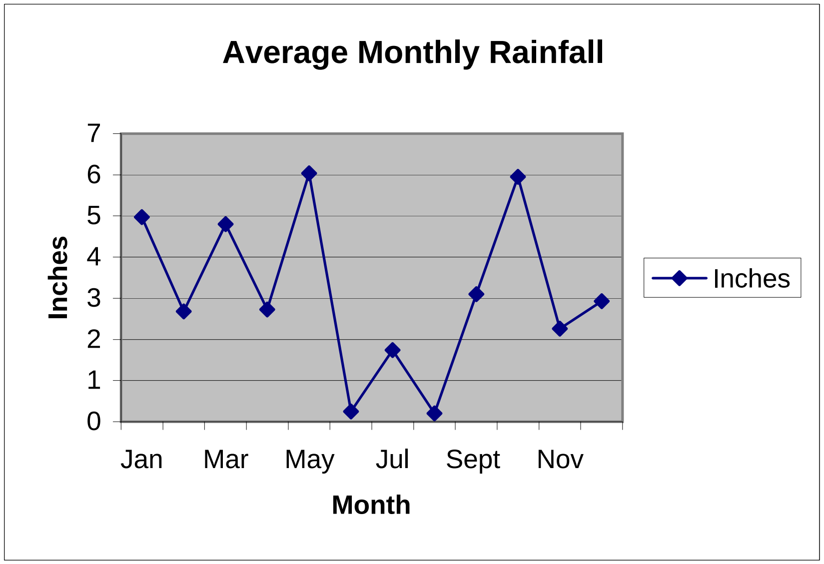
	1	2	3	4	5	6a	6b	6c	7	8
12-May	0.32	0.15	0.07	1.51	0.05	0.54	0.22	0.93	0.02	1.81
9-Jun	3.06	0.23	0.12	0.22	0.05	1.59	0.41	0.73	0.02	2.18
12-Jul	0.67	0.03	0.04	0.49	0	0.08	0.89	0.01	0	1.87
8-Aug	0	0	0	0	0	0	0.02	0.05	0	2.92
19-Sep	0	0	0.02	0	0	0	0.02	0	0	1.75
18-Oct	0	0	0	0	0	0	0	0	0	2.16



Appendix E

Average Monthly Rainfall 2005

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Inches	4.97	2.68	4.8	2.73	6.04	0.25	1.74	0.2	3.1	5.95	2.26	2.93



Total Rainfall: 37.65 "